# APPARATUS AND METHOD FOR APPLYING CHEMICALS TO SUBSTRATES VIA THE USE OF NONAQUEOUS SOLVENTS

## PRIORITY CLAIM

This application claims the benefit of priority to provisional application number 60/394,212, filed in the United States on July 3, 2002, and titled "Water repelling and recycling device".

## FIELD OF INVENTION

The present invention relates to an apparatus and method for applying chemicals to substrates through a continuous process, and more specifically, to a machine using non-aqueous solvents as a carrier medium for the chemicals, with the non-aqueous solvents being evaporated away and leaving the chemicals on the substrates, and with the non-aqueous solvents thereafter continuously condensed, purified and recycled through the machine while the process runs.

## BACKGROUND OF INVENTION

It is often desirable that substrates, such as textiles, be treated to enhance certain properties, such as fire or water resistance. This is often accomplished through an addition of chemicals to the substrates in order to impart the desired properties..

Historically, the addition of chemicals to substrates has been accomplished through aqueous-based systems, requiring large amounts of energy and expensive drying systems. Traditionally, chemicals have been applied to substrates using a batch method wherein substrates are dis-continuously run through a machine. The substrates are introduced into the machine, and the machine is shut down after the completion of each batch in order to remove and dry the treated substrates and to insert new substrates into the machine.

The traditional batch method does not effectively recycle solvents; the machine is frequently shut down in order reclaim any solvent. The solvent is then sent off to a recovery site while new or recovered solvent is added into the machine. The inefficient recycling of solvents results in chemical exhaust and waste, creating special environmental problems and requiring regulation by the Environmental Protection Agency.

Therefore, there exists a need for an apparatus that applies chemicals to substrates through a continuous process, using non-aqueous and environmentally friendly solvents, thereby reducing costs and improving quality of treated substrates.

The apparatus in the present invention fulfills this need in two aspects. First, the present invention provides a process whereby substrates can be continuously fed into and removed from the apparatus without having to stop the process. Second, the apparatus actually purifies any contaminated solvent and continuously reintroduces any reclaimed solvent back to the process.

## SUMMARY OF INVENTION

The apparatus of the present invention comprises a machine for applying chemicals to substrates via the use of non-aqueous solvents. The machine has an application chamber portion containing an application apparatus. The application apparatus is adapted to introduce a chemical mixture into contact with a substrate, forming a wet substrate. The chemical mixture is comprised of a non-aqueous solvent and a chemical solute. A removal portion is connected with the application portion, wherein the non-aqueous solvent is removed from the wet substrate, leaving a substrate with remaining chemical solution.

In another aspect, the application apparatus is an item selected from a group consisting of a foam applicator, spray applicator, and a padding applicator.

In addition, the removal portion comprises a removal apparatus for removing a portion of the chemical mixture from the wet substrate, leaving a substrate with remaining chemical mixture; a vacuum chamber in fluid communication with the removal apparatus for lowering a boiling point of the non-aqueous solvent in the substrate with remaining chemical mixture; and an evaporator apparatus connected with the vacuum chamber to evaporate the non-aqueous solvent into a solvent vapor.

In addition, the removal apparatus may be a squeeze roller; the evaporator apparatus may be a heat exchanger; and the heat exchanger may be a steam-based heat exchanger.

In another aspect, a blower apparatus is in fluid communication with the machine, creating a negative pressure and thereby preventing vapors from escaping. Additionally, a separator is connected with the blower apparatus to remove remaining solvent vapors.

In addition, the blower apparatus is an item selected from a group consisting of a fan, and a blower.

In yet another aspect, the separator comprises a mist eliminator and a high efficiency separator, further removing solvent vapors.

In another aspect of the present invention, the machine has a collector portion for collecting any removed non-aqueous solvent.

In another aspect, the collector portion comprises a vapor scrubber chamber, where the solvent vapor is pushed into the vapor scrubber chamber via a negative pressure difference between the vapor scrubber chamber and surrounding areas; a condensing apparatus associated with the vapor scrubber chamber, condensing the solvent vapor into a condensed liquid solvent solution; a re-boiler tank in fluid

communication with the vapor scrubber chamber and the removal apparatus, the re-boiler tank collecting the condensed liquid solvent solution and the portion of the chemical mixture into a collected solution, where the collected solution is heated to vaporize the non-aqueous solvent into a re-vaporized non-aqueous solvent; a cooling chamber connected with the re-boiler tank, where the re-vaporized non-aqueous solvent is condensed into a re-condensed non-aqueous solvent; and a recovery tank associated with the cooling chamber to collect the re-condensed non-aqueous solvent.

Furthermore, the condensing apparatus may be a water spray mechanism; and the re-boiler tank may be heated through a steam-based heat exchanger.

Furthermore, the re-condensed non-aqueous solvent may be pumped from the recovery tank to a mix tank, where it may be combined with appropriate chemicals to create the chemical mixture, or pumped directly to the application apparatus.

Additionally, the chemical mixture may be optionally pumped to an additional application apparatus, where it is applied to an additional side of the substrate.

In another aspect, the present invention comprises a method for applying a chemical solution to a substrate. The method comprises the acts of forming a chemical mixture comprising a non-aqueous solvent and a chemical solute; applying the chemical mixture with the substrate, forming a wet substrate; and removing the non-aqueous solvent from the wet substrate, leaving substrate with remaining chemical solution.

In yet another aspect, the method for applying a chemical solution to a substrate further comprises an act of selecting an application apparatus before the act of applying the chemical mixture to the substrate, the application apparatus being selected from a group consisting of a foam applicator, spray applicator, and a padding applicator.

In another aspect, the act of removing the non-aqueous solvent from the wet substrate comprises acts of removing a portion of the chemical mixture from the wet substrate, leaving a substrate with remaining chemical mixture; lowering a boiling point of the non-aqueous solvent in the substrate with remaining chemical mixture; and evaporating the non-aqueous solvent into a solvent vapor.

In addition, the method for applying a chemical solution to a substrate further comprises an act of using a squeeze roller as a removal apparatus, before the act of removing a portion of the chemical mixture from the wet substrate.

Furthermore, the method for applying a chemical solution to a substrate further comprises an act of using a heat exchanger as an evaporator apparatus, before the act of evaporating the non-aqueous solvent into a solvent vapor.

Additionally, the method for applying a chemical solution to a substrate further comprises an act of using a steam-based heat exchanger as the heat exchanger.

In another aspect, the method for applying a chemical solution to a substrate, further comprises an act of preventing vapors from escaping by creating a negative pressure; and removing remaining solvent vapors.

In addition, the method for applying a chemical solution to a substrate further comprises an act of selecting a blower apparatus before the act of preventing vapors from escaping by creating a negative pressure. The blower apparatus is selected from a group consisting of a fan, and a blower.

In yet another aspect, the method for applying a chemical solution to a substrate further comprises an act of using a separator comprising a mist eliminator and a high efficiency separator, before the act of removing remaining solvent vapors.

In another aspect, the method for applying a chemical solution to a substrate, further comprises an act of collecting any removed non-aqueous solvent.

In yet another aspect, the act of collecting any removed non-aqueous solvent comprises acts of pushing the solvent vapor into a vapor scrubber chamber via a negative pressure difference between the vapor scrubber chamber and surrounding areas; condensing the solvent vapor into a condensed liquid solvent solution; collecting the condensed liquid solvent solution and the portion of the chemical mixture into a collected solution; heating the collected solution to vaporize the non-aqueous solvent into a re-vaporized non-aqueous solvent; cooling and condensing the re-vaporized non-aqueous solvent into a re-condensed non-aqueous solvent; and collecting the re-condensed non-aqueous solvent.

In yet another aspect, method for applying a chemical solution to a substrate further comprises an act of using a water spray mechanism as a condensing apparatus, before the act of condensing the solvent vapor into a condensed liquid solvent solution.

In another aspect, the method for applying a chemical solution to a substrate further comprises an act of using a steam-based heat exchanger as the method for heating a re-boiler tank, before the act of heating the collected solution to vaporize the non-aqueous solvent into a re-vaporized non-aqueous solvent.

Additionally, the method for applying a chemical solution to a substrate further comprises an act of pumping the re-condensed non-aqueous solvent from the recovery tank to a mix tank, where it may be combined with appropriate chemicals to create the chemical mixture.

In addition, the method for applying a chemical solution to a substrate further comprises an act of pumping the chemical mixture to the application apparatus, and optionally, to the additional application apparatus.

In another aspect of the present invention, the present invention comprises a machine for applying a chemical solution to a substrate. The machine comprises a means for forming a chemical mixture comprising a non-aqueous solvent and a chemical solute; a means for applying the chemical mixture with the substrate, forming a wet substrate; and a means for removing the non-aqueous solvent from the wet substrate, leaving substrate with remaining chemical solution.

Additionally, the means for applying the chemical mixture with the substrate, forming a wet substrate, is an item selected from a group consisting of a foam applicator, spray applicator, and a padding applicator.

In addition, the means for removing the non-aqueous solvent from the wet substrate comprises a means for removing a portion of the chemical mixture from the wet substrate, leaving a substrate with remaining chemical mixture; a means for lowering a boiling point of the non-aqueous solvent in the substrate with remaining chemical mixture; and a means for evaporating the non-aqueous solvent into a solvent vapor.

In addition, the means for removing a portion of the chemical mixture from the wet substrate may be a squeeze roller; the evaporating means is a heat exchanger; and the heat exchanger is a steam-based heat exchanger.

In yet another aspect, the machine for applying a chemical solution to a substrate further comprises a means for preventing vapors from escaping by creating a negative pressure; and a means for removing remaining solvent vapors.

In another aspect, the means for preventing vapors from escaping by creating a negative pressure, is an item selected from a group consisting of a fan, and a blower.

Additionally, the means for removing remaining solvent vapors, is a mist eliminator and a high efficiency separator.

In another aspect, the machine for applying a chemical solution to a substrate further comprises a means for collecting any removed non-aqueous solvent.

Furthermore, the means for collecting any removed non-aqueous solvent comprises a means for pushing the solvent vapor into a vapor scrubber chamber via a negative pressure difference between the vapor scrubber chamber and surrounding areas; a means for condensing the solvent vapor into a condensed liquid solvent solution; a means for collecting the condensed liquid solvent solution and the portion of the chemical mixture into a collected solution; a means for heating the collected solution to vaporize the non-aqueous solvent into a re-vaporized non-aqueous solvent; a means for cooling and condensing the re-vaporized non-aqueous solvent into a re-condensed non-aqueous solvent; and a means for collecting the re-condensed non-aqueous solvent.

Furthermore, the condensing means is a water spray mechanism; and the means for heating the collected solution to vaporize the non-aqueous solvent into a re-vaporized non-aqueous solvent, is a steam-based heat exchanger.

Furthermore, the machine for applying a chemical solution to a substrate further comprises a means for pumping the re-condensed non-aqueous solvent from the recovery tank to a mix tank. Once in the mix tank, it may be combined with appropriate chemicals to create the chemical mixture.

Further, the machine for applying a chemical solution to a substrate further comprises a means for pumping the chemical mixture to the application apparatus, and optionally, to an additional application apparatus.

Finally, the machine for applying a chemical solution to a substrate, further comprises a means for applying the chemical mixture to an additional side of the substrate.

## BRIEF DESCRIPTION OF THE DRAWINGS

The nature of the machine and the process described herein will be readily apparent in the following drawings, in which:

FIG. 1 is a side perspective view of a machine operating according to the present invention, cut away to illustrate the interior of the machine;

FIG. 2 is a side perspective view of a machine operating according to the present invention, cut away to illustrate the interior of the machine and to demonstrate the treatment of vapors and solvents; and

FIG. 3 is a flow chart, demonstrating acts performed by the present invention.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to an apparatus for applying chemicals to substrates, and more specifically, to a machine using non-aqueous solvents as a carrier medium for the chemicals, with the solvents being evaporated away and leaving the chemicals on the substrates. Further, the machine may apply the chemicals directly or indirectly to the substrates, with the solvents again being evaporated away and leaving the chemicals on the substrates. The following description, taken in conjunction with the referenced drawings, is presented to enable one of ordinary skill in the art to make and use the invention. Various modifications will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to a wide range of aspects. Thus, the present invention is not intended to be limited to the aspects presented, but is to be accorded the widest scope consistent with the principles and novel features disclosed herein. Furthermore it should be noted that unless explicitly stated otherwise, the figures

included herein are illustrated diagrammatically and without any specific scale, as they are provided as qualitative illustrations of the concept of the present invention.

Referring to the figures, FIG. **1** illustrates an aspect of the machine **100** in accordance with the present invention. The machine **100** has an application chamber portion **102**, where a substrate **104** is introduced with a chemical mixture via an application apparatus **106**, forming a wet substrate. The substrate **104** is constructed of at least one layer of any suitable material, non-limiting examples of which include textile, non-woven textile, paper, and leather. The chemical mixture is comprised of a non-aqueous solvent and a chemical solute. The non-aqueous solvent is comprised of at least one suitable carrier medium. For example, the non-aqueous solvent may be comprised of n-propyl bromide. For a more thorough understanding of suitable carrier mediums, please see attached Appendix A. Attached hereto as Appendix A is non-provisional utility application, which outlines a chemical formulation using non-aqueous carrier mediums to apply fluorocarbons and other organic chemicals to textile substrates. Further, the chemical solution is comprised of at least one suitable solute, non-limiting examples of which include fluorocarbons, fire-retardants, anti-stats, anti-microbials, and UV inhibitors.

The chemical mixture may be separately formed and introduced to the application apparatus **106**; mixed in a mix tank **107** and introduced to the application apparatus **106**; or pumped directly from a recovery tank **108** to the application apparatus **106**. The application apparatus **106** takes the form of any suitable apparatus for applying the chemical mixture with the substrate **104**, non-limiting examples of which include a foam applicator, a spray applicator, and a padding applicator.

After introducing the chemical mixture with the substrate **104**, the substrate **104** then interacts with a removal portion. The removal portion comprises a removal apparatus **109**, a vacuum chamber **110**, and an evaporator apparatus **112**. Upon entering the removal portion, the substrate **104** interacts with the removal apparatus **109**, where a

portion of the chemical mixture is removed from the substrate **104**. The removal apparatus **109** may be any suitable apparatus for removing excess chemical mixture from the substrate **104**. For example, the removal apparatus **109** may be a squeeze roller. In this aspect, the substrate **104** passes through the squeeze roller where excess chemical mixture is squeezed from the substrate **104**, leaving a substrate with remaining chemical mixture. After interacting with the removal apparatus **109**, the substrate with remaining chemical mixture may optionally interact with an additional application apparatus **113**, where the chemical mixture is applied to an additional side of the substrate **104**.

After interacting with the removal apparatus **109**, the substrate with remaining chemical mixture then enters a vacuum chamber **110**, where negative pressure lowers a boiling point of the non-aqueous solvent. In the vacuum chamber **110**, the substrate with remaining chemical mixture interacts with an evaporator apparatus **112**. The evaporator apparatus **112** is used to evaporate the non-aqueous solvent into a solvent vapor, thereby removing the non-aqueous solvent from the substrate **104**. The evaporator apparatus **112** may be any suitable apparatus for evaporating the non-aqueous solvent. For example, the evaporator apparatus **112** may be a heat exchanger. Further, the heat exchanger may be a steam-based heat exchanger, where steam is passed through the heat exchanger, providing a sufficient amount of heat to evaporate the non-aqueous solvent. After having come in contact with the evaporator apparatus **112**, the substrate **104** then leaves the vacuum chamber **110** and subsequently leaves the machine **100** altogether, with the chemical solution remaining and the non-aqueous solvent removed.

As illustrated in FIG. **2**, a blower apparatus **200** is in fluid communication with the machine **100**. The blower apparatus **200** may be any suitable apparatus for displacing air, non-limiting examples of which include a fan, and a blower. The blower apparatus **200** pushes the solvent vapor from the vacuum chamber **110** to a collector portion. The collector portion comprises a vapor scrubber chamber **202**, a condensing apparatus **204**, a re-boiler tank **206**, a cooling chamber **208**, and a recovery tank **108**. The solvent vapors are pushed into the vapor scrubber chamber **202** via a negative pressure

difference between the vapor scrubber chamber **202** and surrounding areas. Associated with the vapor scrubber chamber **202** is a condensing apparatus **204**. The condensing apparatus **204** may be any suitable apparatus for condensing the solvent vapor into a condensed liquid solvent solution, a non-limiting example of which includes a water spray mechanism.

After condensing, the condensed liquid solvent solution then falls into a re-boiler tank **206**. The re-boiler tank **206** also collects the portion of the chemical mixture removed from the substrate **104** by the removal apparatus **109**, combining the two solutions into a collected solution **211**. The collected solution **211** is heated to a temperature less than the boiling point of water, but greater than the boiling point of the non-aqueous solvent, thereby vaporizing the non-aqueous solvent into a re-vaporized non-aqueous solvent. The re-boiler tank **206** may be heated using any suitable means for heating such a tank, a non-limiting example of which includes a steam-based heat exchanger.

The re-vaporized non-aqueous solvent is then pushed via the blower apparatus **200** into a cooling chamber **208**. Once in the cooling chamber **208**, the re-vaporized non-aqueous solvent is condensed into a re-condensed non-aqueous solvent, and thereafter returns to the recovery tank **108**. The cooling chamber **208** may use any suitable means for cooling and condensing a vapor, a non-limiting example of which includes using cooling pipes.

In the recovery tank **108**, there is a small amount of water that condenses with the non-aqueous solvent. The small amount of water readily separates from the non-aqueous solvent due to differences in specific gravity and is decanted away and out of the machine **100**. After decanting away the small amount of water, the re-condensed non-aqueous solvent is substantially pure and may be recycled through the machine **100**. Through the use of a pump **212**, the re-condensed non-aqueous solvent may be pumped from the recovery tank **108** to a mix tank **107**, where it is combined with appropriate chemicals to

create the chemical mixture. The chemical mixture may then be pumped to the application apparatus **106,** and optionally to the additional application apparatus **113**, where it is applied to a new substrate. Or in the alternative, the re-condensed non-aqueous solvent may be pumped directly from the recovery tank **108** to the application apparatus **106**, and optionally to the additional application apparatus **113**.

Additionally, the blower apparatus **200** creates a negative pressure, preventing vapors from escaping the machine **100**. The negative pressure is defined as a decreasing difference in atmospheric pressure between an internal portion **214** of the blower apparatus **200** and further distanced chambers and areas of the machine **100**, where there exists a high pressure at the further distanced chambers and areas of the machine **100**, and where the blower apparatus **200** creates a low pressure at the internal portion **214** of the blower apparatus **200**. The negative pressure therefore pushes concentrated solvent vapors from the vacuum chamber **110** and the re-boiler tank **206**, and fugitive vapors from the application chamber portion **102**, the vapor scrubber chamber **202**, and the cooling chamber **208,** towards the blower apparatus **200** and through a separator **216**. The separator **216** comprises a mist eliminator and a high efficiency separator. The high efficiency separator is comprised as a component of the separator **216**, further removing moisture molecules from air to a low-micron level, and ensuring that air leaving the system is substantially liquid free. Once in the separator **216**, any remaining vapors are pushed through the mist eliminator and the high efficiency separator, such that any exhaust is air, with solvent vapors removed. Further, all moisture that collects on the mist eliminator is introduced into the separator **216**, where water and the non-aqueous solvent readily separate. The non-aqueous solvent is then returned to the recovery tank **108**, where any remaining water contamination is decanted away.

Illustrated in FIG. **3** are acts performed in applying a chemical solution to a substrate in the scope of the invention. The functions of the machine described above constitute a method, operations of which are described below.

The method comprises an act of forming a chemical mixture **300** comprising a non-aqueous solvent and a chemical solute. Non-limiting examples of which include mixing the non-aqueous solvent and chemical solution separately, and thereafter introducing the chemical mixture to an application apparatus **106**; forming the chemical mixture in a mix tank **107** and thereafter introducing the chemical mixture **107** to the application apparatus **106**; or pumping the chemical mixture directly from a recovery tank **108** to the application apparatus **106**.

The method further comprises an act of applying the chemical mixture to the substrate **302**, forming a wet substrate, a non-limiting example of which includes using an application apparatus **106**. The application apparatus **106** is an item selected from a group consisting of a foam applicator, spray applicator, and a padding applicator. Additionally, the chemical mixture may be applied to an additional side of the substrate through use of an additional application apparatus **113**.

Furthermore, the method comprises an act of removing the non-aqueous solvent from the wet substrate **304**, leaving a substrate with remaining chemical solution. A non-limiting example of which comprises the acts of removing a portion of the chemical mixture from the wet substrate, leaving a substrate with remaining chemical mixture; lowering a boiling point of the non-aqueous solvent in the substrate with remaining chemical mixture; and evaporating the non-aqueous solvent into a solvent vapor.

The act of removing a portion of the chemical mixture from the substrate may be accomplished through use of a removal apparatus **109**, a non-limiting example of which includes a squeeze roller. The act of lowering a boiling point of the non-aqueous solvent may be accomplished through use of a vacuum chamber **110**, thereby decreasing the pressure and lowering the boiling point of the non-aqueous solvent. Furthermore, the act of evaporating the non-aqueous solvent into a solvent vapor may be accomplished through use of an evaporator apparatus **112**, a non-limiting example of which includes a heat-exchanger, or in another aspect, a steam-based heat exchanger.

In addition, the method comprises the acts of preventing vapors from escaping by creating a negative pressure; and removing remaining solvent vapors **306**. The act of preventing vapors from escaping by creating a negative pressure may be achieved through the use of any suitable apparatus for displacing air, a non-limiting example of which includes a blower apparatus **200**. For example, the blower apparatus **200** may take the form of a blower, or a fan. Additionally, the act of removing remaining solvent vapors may be accomplished through the use of a separator **216**, a non-limiting example of which includes a separator **216** comprising a mist eliminator and high efficiency separator.

Furthermore, the method comprises an act of collecting any removed non-aqueous solvent **308**. A non-limiting example of collecting any removed non-aqueous solvent **308**, comprises acts of pushing the solvent vapor into a vapor scrubber chamber **202** via a negative pressure difference between the vapor scrubber chamber **202** and surrounding areas; condensing the solvent vapor into a condensed liquid solvent solution; collecting the condensed liquid solvent solution and the portion of the chemical mixture into a collected solution **211**; heating the collected solution **211** to vaporize the non-aqueous solvent into a re-vaporized non-aqueous solvent; cooling and condensing the re-vaporized non-aqueous solvent into a re-condensed non-aqueous solvent; and collecting the re-condensed non-aqueous solvent.

The act of pushing the solvent vapor into vapor scrubber chamber **202** may be accomplished through use of a blower apparatus **200**, non-limiting examples of which include a blower, or a fan. Additionally, the act of condensing the solvent vapor into a condensed liquid solvent solution may be achieved through use of a condensing apparatus **204**, a non-limiting example of which includes a water spray mechanism. In addition, the act of collecting the condensed liquid solvent solution and the portion of the chemical mixture into a collected solution **211**, and the act of heating the collected solution **211** to vaporize the non-aqueous solvent into a re-vaporized non-aqueous solvent, may be

accomplished through use of a re-boiler tank **206**. Furthermore, the act of cooling and condensing the re-vaporized non-aqueous solvent into a re-condensed non-aqueous solvent, may be achieved through use of a cooling chamber **208**, a non-limiting example of which includes using cooling pipes.

Additionally, the act of collecting the re-condensed non-aqueous solvent may be accomplished through use of any suitable means for collecting a liquid solution, a non-limiting example of which includes use of a recovery tank **108**. Once in the recovery tank **108**, there is a small amount of water that condenses with the non-aqueous solvent. The small amount of water may be readily separated from the non-aqueous solvent due to differences in specific gravity and then further decanted away and out of the machine **100**. After decanting away the small amount of water, the re-condensed non-aqueous solvent is substantially pure and may be recycled through the machine **100**. Through the use of a pump **212**, the re-condensed non-aqueous solvent may be pumped from the recovery tank **108** to a mix tank **107**, where it is combined with appropriate chemicals to create the chemical mixture. The chemical mixture may then be pumped to the application apparatus **106,** and optionally to the additional application apparatus **113**, where it is applied to a new substrate. Or in the alternative, the re-condensed non-aqueous solvent may be pumped directly from the recovery tank **108** to the application apparatus **106**, and optionally to the additional application apparatus **113**.